DO

Formerly Utilized MED/AEC
Remedial Action Pro

Radiological Survey of the Museum of Science and
57th Street and Lake Shore Drive, Chica

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U.S. Departme
Assistant Secretary
Division of Environmental Co
Washingt

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This is one of a series of reports resulting from a program initiated i
974 by the Atomic Energy Commission (AEC) for determination of the conditic
f sites formerly utilized by the Manhattan Engineer District (MED) and the
EC for work involving the handling of radioactive materials. Since the ear
940's, the control of over 100 sites that were no longer required for nucl
rograms has been returned to private industry or the public for unrestricte
se. A search of MED and AEC records indicated that for some of these sites
ocumentation was insufficient to determine whether or not the decontaminati
ork done at the time nuclear activities ceased is adequate by current guide
ines.

This report contains the results of surveys of the current radiological
ondition of the Museum of Science and Industry, 57th Street and Lake Shore
hicago, Illinois. Findings of this survey indicate there is no identifiable
adioactivity remaining at this facility from operations conducted by the ME
EC during the period 1946 thru 1953.

This survey was performed by the following Health Physics personnel of
ccupational Health and Safety Division, Argonne National Laboratory, Argonr
llinois: R. A. Wynveen, W. H. Smith, C. J. Mayes, P. C. Gray, D. W. Reilly

CONTENTS

INTRODUCTION

During the Manhattan Engineer District/Atomic Energy Commission (MED/AEC) Argonne National Laboratory (ANL) occupied space at the Museum of Science ndustry, Chicago, Illinois. From August 15, 1946 until July 1, 1949, ANL ied 36,000 square feet on the ground, first, and balacony floors of the Eas ion. From August 15, 1946 until July 15, 1953, ANL also occupied 16,000 e feet in the 2nd Balcony of the West Court. The actual use of the facili nknown. Although most of the area was believed to be occupied as office e, some handling of radioactive materials was known to have taken place. Th and activity of these materials is unknown.

Personnel involved with the facility during ANL's occupation recalled at t one spill of radioactive material near the service elevator on the ground or of the East Pavilion and its subsquent decontamination.

Due to the uncertainty of the use of the facility, a radiation survey of t ve area was undertaken from January 11, 1977 until April 13, 1977. This su performed on an intermittent basis to minimize the disturbance of the Mus ly operations. The purpose of this survey was to determine if any detectab ntamination remains as a result of the MED/AEC operation.

Part of the ground and main floors of the East Pavilion are presently occ the University of Chicago for storage and office space or are used for supp the Museum's operations. The 2nd Balcony of the West Court is now occupie ffice space by the Museum of Science and Industry and the Academy of Intersc thodology.

General

All accessible original walls were surveyed to a height of seven feet a all accessible floor areas were surveyed. In many areas, the floors and wal had been retiled or painted. Even though these were not the original surfac these areas were surveyed since the capability of detection was adequate to activity on the original structures underneath. A representative selective survey of overheads such as pipes, vents and light fixtures was performed in where the original structures were available. The roof of the East Pavilion also surveyed. See Table 1 and Figure 1 for locations of accessible areas su

Instrumentation

Three types of survey instruments were used (Table 2). An Eberline FM having a detection area of 325 square centimeters (cm^2), utilizing the Eberli PAC-4G-3 electronics, was used to survey the floors. A PAC-4G-3 with a hand- detector, 61cm^2 in area, was used to survey the walls and other accessible ar Double aluminized mylar [~ 0.85 milligrams per square centimeter (mg/cm^2)] windows were used in both detectors. This allows for low energy detection and greater instrument sensitivity. Both of these instruments were initially used in the beta mode. In this mode, the detector responds to a wide energy range of electromagnetic and particulate radiations. When areas were found which in cated a higher count rate than the average instrument background, the instrume as then switched to the alpha mode and a reading of the alpha activity was btained.

An End Window Geiger-Mueller (G-M) Detector, Eberline Model E-500B with a ecial 7/8 inch diameter window held three feet above the floor, was used to de ne general background radiation levels throughout the surveyed area. If an ar ound that had an elevated count rate, a contact reading was obtained.

um-226 (^{226}Ra) calibration source. The PAC-4G-3 instruments were cali-
in the alpha mode using a flat plate infinitely thin Plutonium-239 (^{239}
rd and in the beta mode with a flat plate infinitely thin Strontium-90-
m-90 (^{90}Sr-^{90}Y) standard. The instruments were calibrated to an apparen
ometry.

t must be realized that the numerous isotopes that could be encountered
xhibit emission energies differing from that of ^{239}Pu and ^{90}Sr-^{90}Y utili
calibration. When detecting known isotopes that emit alpha and beta
es differing from that of the standards, a conversion factor is develope
ermine the appropriate yield.

Surveys

mears were taken throughout the East Pavilion and West Balcony areas of
. Only original structures and components such as walls, floors, pipes
were smeared. All smears were taken with No. 1 Whatman filter paper, 4.
eters (cm) in diameter. Smears of one square foot were normally taken.
a was found which had a higher than normal background, a smear of 100cm^2
A smear of 100cm^2 was also taken if an area indicated excessive dirt 1
ears were counted in groups of ten using the 10-Wire Flat Plate Gas
tional Detector, developed at ANL, utilizing an Eberline Mini Scaler Mod
One smear of each group was removed and counted in a Nuclear Measuremer
ation Proportional Counter - 3A (PC-3A) 2π Internal Gas Flow Counter usi
r spun top. This procedure was used as an additional means of checking
samples. In addition, any smears indicating elevated amounts in the 10-
ly, were also counted in the more sensitive PC-3A counter. Smears were
d in both detectors for alpha and beta activity. Appendix 1 includes the
mentation and smear count conversion factors used.

of the smears. A number, n, indicates the location
hat smear in the room. A number, (n), indicates a smear of an overhead
tructure. A number [n], indicates an elevated direct reading.

ir Samples

Air samples were collected using a Filter Queen air sampling device.
ir samples were taken at a flow rate of 15 cubic meters per hour (M^3/hr)
00cm^2 sheet of Hollingsworth-Vose (HV-70-9 mil) filter media which collec
e particulates present in the air. A 10% portion, 5cm in diameter, was
om the filter media and counted in the NMC PC-3A 2π Internal Gas Flow Co
ilizing a mylar spun top for both alpha and beta activity. Sampling res
re used to determine radon concentrations and the presence of any long-l
tivity. Air sample data is presented in Appendix 2.

il Samples

In addition to the survey inside the building, soil corings were taker
ected locations outside the East Pavilion of the Museum to determine the
osition, if any, of isotopes that could have been spilled or released fr
t Pavilion. Radiochemical (fluorometric) and gamma spectrum analysis we
ducted on these soil samples.

The corings were effected using a four (4) inch in diameter by six (6)
ength right circular cylinder; commonly called a hole cutter. This devi
ormally used for cutting holes for the cups in golf courses.

Each core was 1 foot in length and divided into four (4) segments. Sta
the surface, three (3) separate two (2) inch segments are cut, bagged,
ed A, B and C respectively; the final segment a six (6) inch section was
ed D.

t migration has occurred, to reduce the dilution of lower level soil with
er level segments in respect to the surface deposition of the contaminants
e versa, and to reveal any overburden or back fill that may have occurred
r the years.

Three soil samples were taken from the grounds adjacent to the East Pavi
the Museum. Figure 1F indicates the soil sample locations.

Background data for the soil sample analysis (Table 8) were obtained
umber of soil samples taken from the Chicago area. This information was
ained from the Environmental Monitoring Section of the Occupational Health
ety (OHS) Division of ANL.

All soil samples were processed at ANL (Figure 3) and shipped to a comm
oratory (LFE Environmental Analysis Laboratories) for radiochemical
uorometric) and gamma spectrum analysis. Their soil analysis procedure is
ibed in Table 6,

Sample preparation consisted of weighing the samples in their entirety a
n drying for approximately 24 hours at 80° Centigrade. All samples were t
eighed, put into mill jars (2.3 gallon) and milled until a sufficient amou
the soil sample would pass a No. 30 standard sieve. At no point were the
heavy material ground or pulverized since this material would act as a di
hence lower the concentration per unit volume of deposited material.

After sufficient milling, the material was sieved using a No. 30, 600 mi
standard stainless sieve. The rocks and dross vs. sieved material (< 600
segregated, bagged, and weighed separately. Soil sample weights are give
Table 5.

radiochemical (fluorometric) only. Every effort was made throughout preparation operations to reduce or eliminate cross contamination. S which were suspected of containing elevated amounts of radioactivity processed in equipment separate from the soil samples considered to c ground levels. All items of equipment were scrubbed and air dried pr introduction of the next sample.

ANALYSIS OF SURVEY RESULTS

General

All data, including diagrams of survey locations, are attached t This section discusses the results of the survey and the findings the Instrument readings and smear results were normalized to units of dis per minute per one hundred square centimeters (dpm/100cm^2). (See Ap for the conversion factors used.) All data is reported in net counts background counts have been subtracted from the gross counts prior t from counts per minute per one hundred square centimeters (cpm/100cm dpm/100cm^2. The beta mode readings are compensated for any alpha co The room background levels varied somewhat due to the construction m them. Table 3 provides an average background reading for all mode different instruments used.

The areas accessible for survey varied from room to room. Area for survey are presented in Table 1. The average percent of the tot areas was 50% for the floors and 40% for the walls.

All indicated areas were surveyed and no radioactivity above backgrou
uld be detected except in the following four rooms.

Room C-340 - This room is a small instrument shop where a marked Coba
^{60}Co) source was found in the cabinet. A direct reading with an End Wind
tector was 80 milliRoentgens per hour (mR/hr) at contact. When the dete
s held three feet away from the source in its shielded container, no rad
ove background levels, < 0.03 mR/hr, could be detected.

Room E-201 and Restrooms on 2nd Balcony - These washrooms contained a
le on the floors. This tile was also noted in other restrooms of the Mu
ese tiles indicated 8.1 x 10^3 dpm/100cm^2 Potassium-40 (^{40}K) with the PAC
the beta mode. No alpha activity was detected. No radiation above bac
vels could be found from the tile using the End Window G-M Detector. No
tivity was detected from floor tile smears. It was determined from a ga
ectral analysis that the tile contained elevated amounts of (^{40}K) which
use an elevated reading. (See Figure 2 for gamma emission spectra.) A
neral background readings taken at three feet above the floor level were
an 0.03 mR/hr.

ear Surveys

No contamination above background levels was detected on any smears.

r Samples

The air sampling results are presented in Table 4. The variation of t
ults do not appear to be a result of any MED/AEC operation, but rather t
on reflects the differences in the construction materials used throughou
ility. Other factors such as the ventilation of the room can cause the
trations to vary. All radon concentrations determined are below the max
e concentrations (MPC) for an uncontrolled area as listed in the "Standa
tection Against Radiation," Code of Federal Regulations, Title 10, Part

Samples

Results submitted by LFE Environmental Analysis Laboratories, as listed in
e 7, are reported in picocuries per gram (pCi/g) for the Germanium (Lithium)
Li)] spectral analysis and in micrograms per gram (μg/g) for the uranium
rometric analysis. The latter concentrations were converted to pCi/g by mea
ne example calculation as shown in Appendix 3.

The background data is presented in Table 8. The background samples indica
al uranium concentrations ranging from 0.03 to 2.0 pCi/g. Results of soil
les taken at the Museum of Science and Industry indicate a gerneral normal u
ground concentration in the soil.

FINDINGS

The survey results show that no radioactive contamination above background
cted throughout the areas used for MED/AEC activities. However, a small ^{60}C
ce which was used as a static eliminator was found in Room C-340. The floor
s which were used in the restrooms, showed elevated levels of naturally occu
^{40}K. Neither of these are a result of any MED/AEC operations. The results
soil sample analysis shows no elevated readings above the natural background
ls present in the soil from this region.

Room or Area No.	Percent of Area Accessible for Survey Floor	Percent of Area Accessible for Survey Wall	Air Sample (pCi/ℓ)	Beta Mode[1] Direct Readings (dpm/100cm²) Floors	Beta Mode[1] Direct Readings (dpm/100cm²) Walls	Beta Mode[1] Direct Readings (dpm/100cm²) Overhead	Beta Mode[1] Direct Readings (dpm/100cm²) Other	Alpha Mode Direct Readings (dpm/100cm²) Floors	Alpha Mode Direct Readings (dpm/100cm²) Walls	Alpha Mode Direct Readings (dpm/100cm²) Overhead	Alpha Mode Direct Readings (dpm/100cm²) Other	End Window (mR/hr) Contact	End Window (mR/hr) 3 feet	Smear Results (dpm/100cm²)
E-1	70	20	NS[2]	BKGD[3]	BKGD	OSU[4]	BKGD	NA[6]	NA	NA	NA	NN[7]	BKGD	BKGD
E-2	80	25	1.25	BKGD	BKGD	OSU	NE[5]	NA	NA	NA	NA	NN	BKGD	BKGD
E-3	70	20	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD
E-4	60	25	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD
E-4A	40	25	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-4AA	40	30	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD
E-7	95	30	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-8	40	40	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-9	50	50	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-11	50	50	NS	BKGD	BKGD	KBGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-12	40	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-14	60	50	0.48	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-15	20	10	0.48	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-16	20	20	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-17	50	50	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD
E-18	30	20	1.5	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD
E-19	20	20	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD

(1) Beta Mode detects both electromagnetic and particulate radiation.

(2) NS – (Not Selected) Air sample locations were chosen on a selected basis throughout the areas surveyed.

(3) BKGD (Background) Instrument Background Readings

	Beta Mode	Alpha Mode
Floor Monitor	1500–2000 cpm/325cm²	0–50 cpm/325cm²

(4) OSU (Overhead Stucture Unavailable) Floor and wall sur
necessity to demolish existing structures to reach ori

(5) NE (Non-Existant) This location did not contain stru
as "other" such as the following: ducts, louvers, pi

(6) NA (Not Applicable) No activity detected above backg
therefore, no alph mode survey was necessary.

(7) NN (Not Necessary) No activity was detected; therefor

DATA SHEETS SHOWING ROOM SURVEY RESULTS

om or ea No.	Percent of Area Accessible for Survey Floor	Wall	Air Sample (pCi/ℓ)	Beta Mode[1] Direct Readings (dpm/100cm²) Floors	Walls	Overhead	Other	Alpha Mode Direct Readings (dpm/100cm²) Floors	Walls	Overhead	Other	End Window (mR/hr) Contact	3 feet	Smear Results (dpm/100cm²)	Comments
-20	80	50	NS[2]	BKGD[3]	BKGD	OSU[4]	BKGD	NA[6]	NA	NA	NA	NN[7]	BKGD	BKGD	
-21S	1	5	NS	BKGD	BKGD	BKGD	NE[5]	NA	NA	NA	NA	NN	BKGD	BKGD	
-21N	20	20	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
airwell f E-14	90	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
100	40	10	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
101	30	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
102	70	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
103	50	30	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
104	40	20	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
105	30	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
105B	30	20	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
106	40	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
108	50	75	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
109	30	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
110 112	40	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
114 117N	75	50	0.49	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	

(1) Beta Mode detects both electromagnetic and particulate radiation

(2) NS-(Not Selected) Air sample locations were chosen on a selected basis throughout the area surveyed.

(3) BKGD (Background) Instrument Background Readings.

	Beta Mode	Alpha Mode
Floor Monitor	1500-2000 cpm/325cm²	0-50 cpm/325cm²
PAC-4G-3	150-200 cpm/61cm²	0-50 cpm/61cm²

(4) OSU (Overhead Structure Unavailable) Floor and wall survey indicat necessity to demolish existing structures to reach original overhe

(5) NE (Non-Existant) This location did not contain structural items c as "other" such as the following: ducts, louvers, pipes and vents.

(6) NA (Not Applicable) No activity detected above background in the b therefore, no alpha mode survey was necessary.

(7) NN (Not Necessary) No activity was detected; therefore, no contact

r o.	Percent of Area Accessible for Survey Floor	Wall	Air Sample (pCi/ℓ)	Beta Mode[1] Direct Readings (dpm/100cm²) Floors	Walls	Overhead	Other	Alpha Mode Direct Readings (dpm/100cm²) Floors	Walls	Overhead	Other	Gamma Readings (mR/hr) Contact	3 feet	Results (dpm/100cm²)	Comments
S	20	10	0.71	BKGD[3]	BKGD	OSU[4]	NE[5]	NA[6]	NA	NA	NA	NN[7]	BKGD	BKGD	
	80	60	BLGD	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
	50	10	NS[2]	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
ium us	50	50	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
1	80	50	1.04	$8.3x10^3$	BKGD	OSU	NE	BKGD	NA	NA	NA	BKGD	BKGD	BKGD	Floor tile in wa
2	50	30	0.67	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
3	50	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
or 11	100	50	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
or all	100	60	0.31	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
	100	60	NS	$8.3x10^3$	BKGD	BKGD	NE	BKGD	NA	NA	NA	BKGD	BKGD	BKGD	Floor Tile
n	60	50	NS	$8.3x10^3$	BKGD	BKGD	NE	BKGD	NA	NA	NA	BKGD	BKGD	BKGD	Floor Tile
	80	10	NS	BKGD	BKGD	OSU	$9.6x10^2$	NA	NA	NA	BKGD	80	BKGD	NST[8]	^{60}Co Source Read with source in
	80	20	NS	BKGD	BKGD	OSU	BKGS	NA	NA	NA	NA	NN	BKGD	BKGD	
	60	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	

eta Mode detects both electromagnetic and particulate radiation.

S – (Not Selected) Air sample locations were chosen on a selected asis throughout the areas surveyed.

KGD (Background) Instrument Background Readings

	Beta Mode	Alpha Mode
loor Monitor	1500–2000 cpm/325cm²	0–50 cpm/325cm²
AC-4G-3	150–200 cpm/61cm²	0–50 cpm/61cm²

(4) OSU (Overhead Structure Unavailable) Floor and wall survey indicate necessity to demolish existing structures to reach original overhead

(5) Ne (Non-Existant) This location did not contain structural items clas as "other" such as the following: ducts, louvers, pipes and vents.

(6) NA (Not Applicable) No activity detected above background in the beta therefore, no alpha mode survey was necessary.

(7) NN (Not Necessary) No activity was detected; therefore, no contact G- Winder Survey was necessary.

TABLE I

DATA SHEETS SHOWING ROOM SURVEY RESULTS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample	Beta Mode[1] Direct Readings (dpm/100cm^2)				Alpha Mode Direct Readings (dpm/100cm^2)				End Window (mR/hr)		Smear Results (dpm/100cm^2)	Comments
	Floor	Wall	(pCi/ℓ)	Floors	Walls	Overhead	Other	Floors	Walls	Overhead	Other	Contact	3 feet		
C-343 C-244A C-345	15	15	NS[2]	BKGD[3]	BKGD	OSU[4]	BKGD	NA[6]	NA	NA	NA	NN[7]	BKGD	BKGD	
346, 347 48, 349, 54,355, 56, 357 58	30	20	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
nd Floor alcony est Hall	100	50	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
nd Floor alcony orth Hall	100	50	0.31	BKGD	BKGD	OSU	NE[5]	NA	NA	NA	NA	NN	BKGD	BKGD	
C-359	15	20	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
C-360	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
C-361	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
C-362	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
C-363	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
C-364	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
C-365	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
C-366 C-367	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	
Roof	100	100	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD	BKGD	

(1) Beta Mode detects both electromagnetic and particulate radiation.

(4) OSU (Overhead Structure Unavailable) Floor and wall survey in

SURVEY LOCATIONS OF EAST PAVILION - GROUND FLOOR

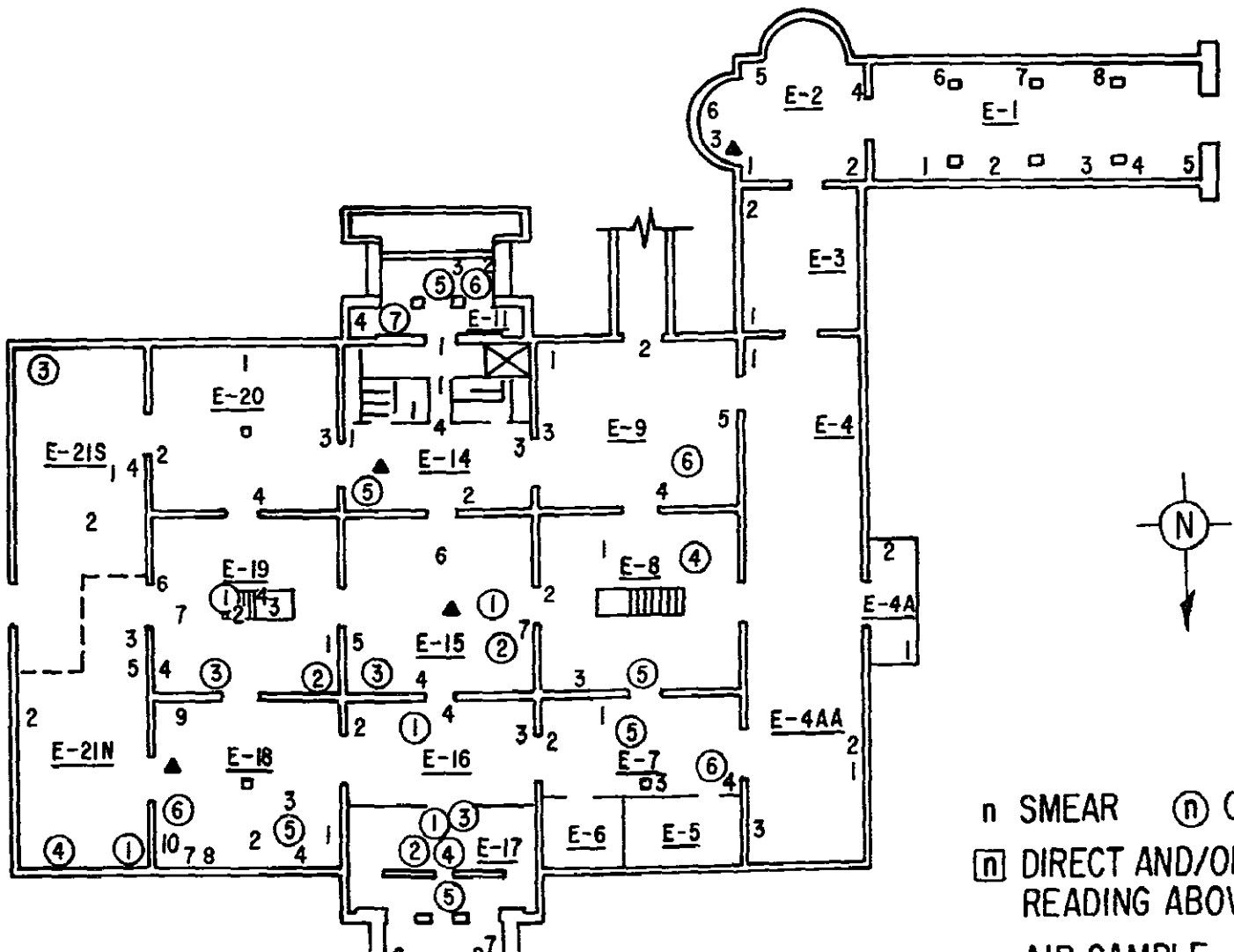


FIGURE 1B

SURVEY LOCATIONS OF EAST PAVILION - FIRST FLOOR

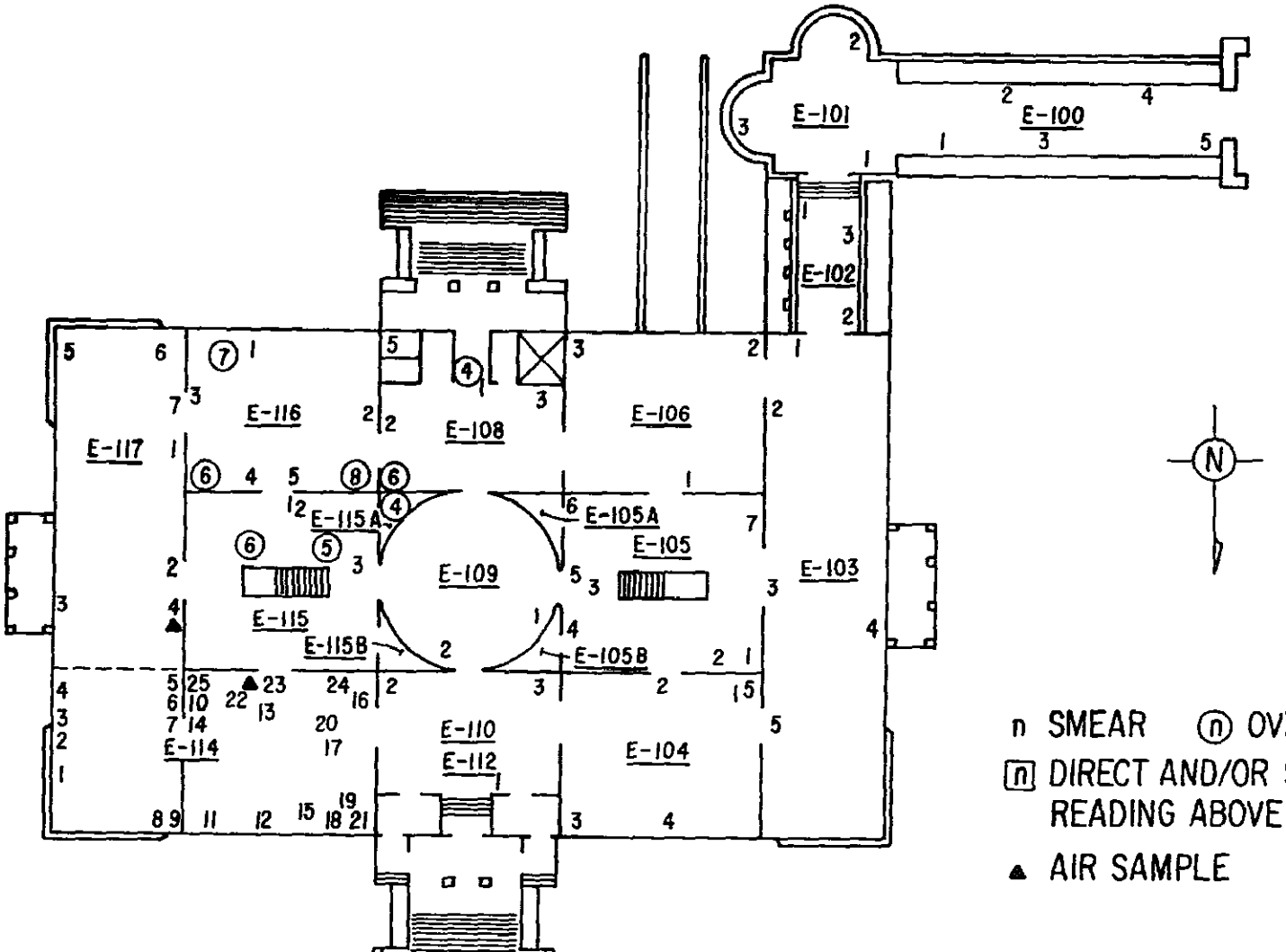


FIGURE 1C

SURVEY LOCATIONS OF EAST PAVILION - FIRST BALCONY

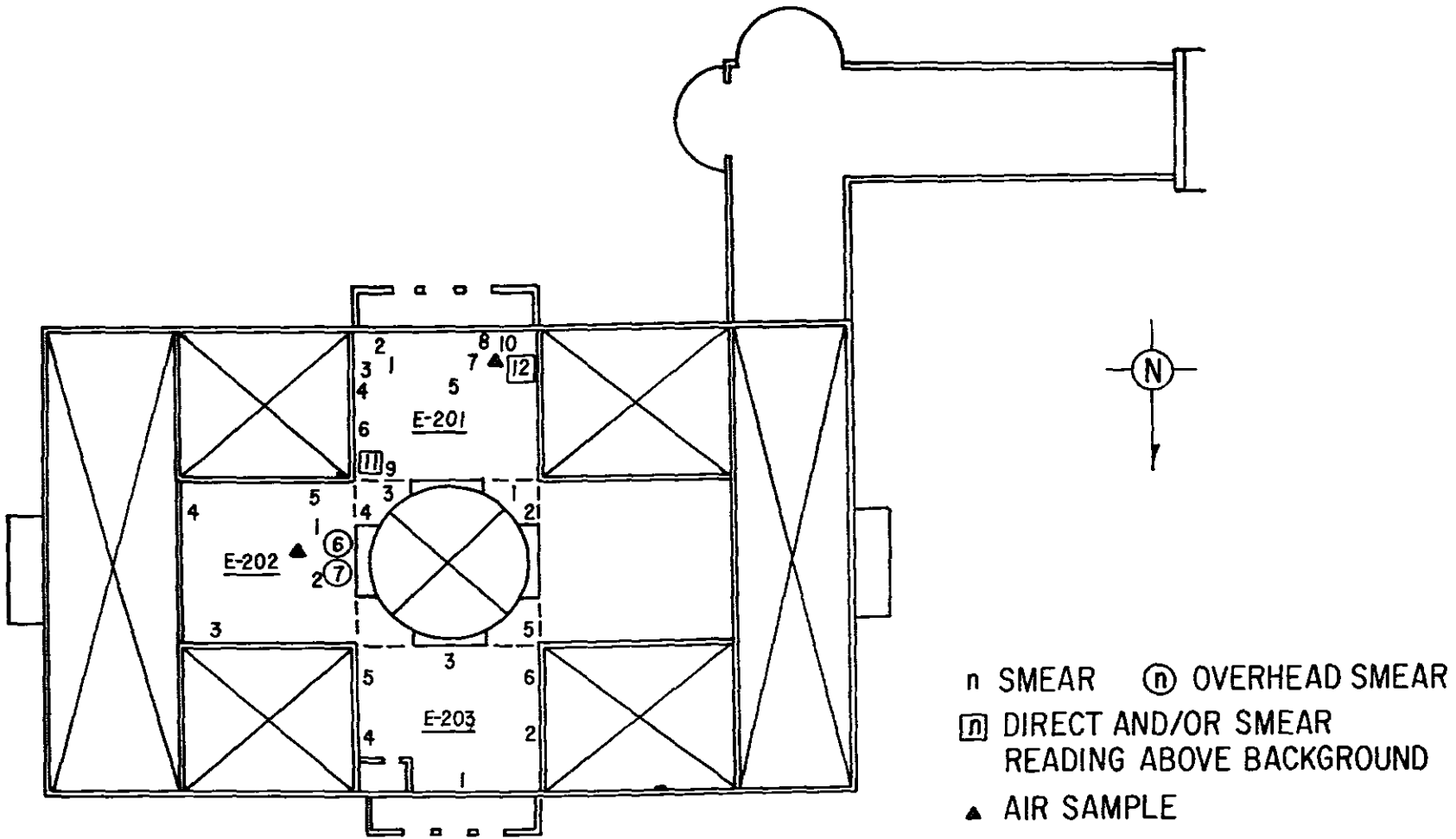
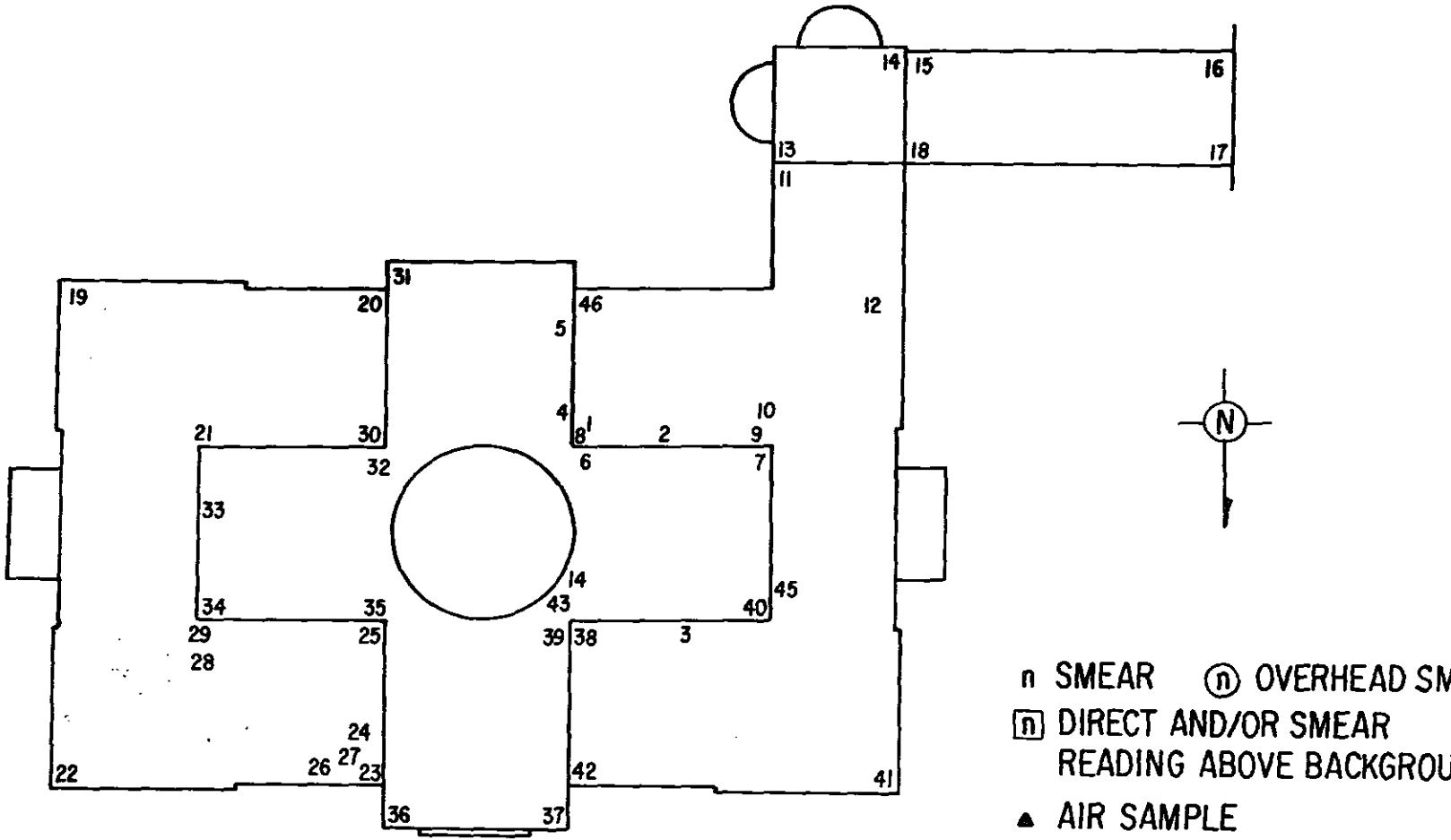
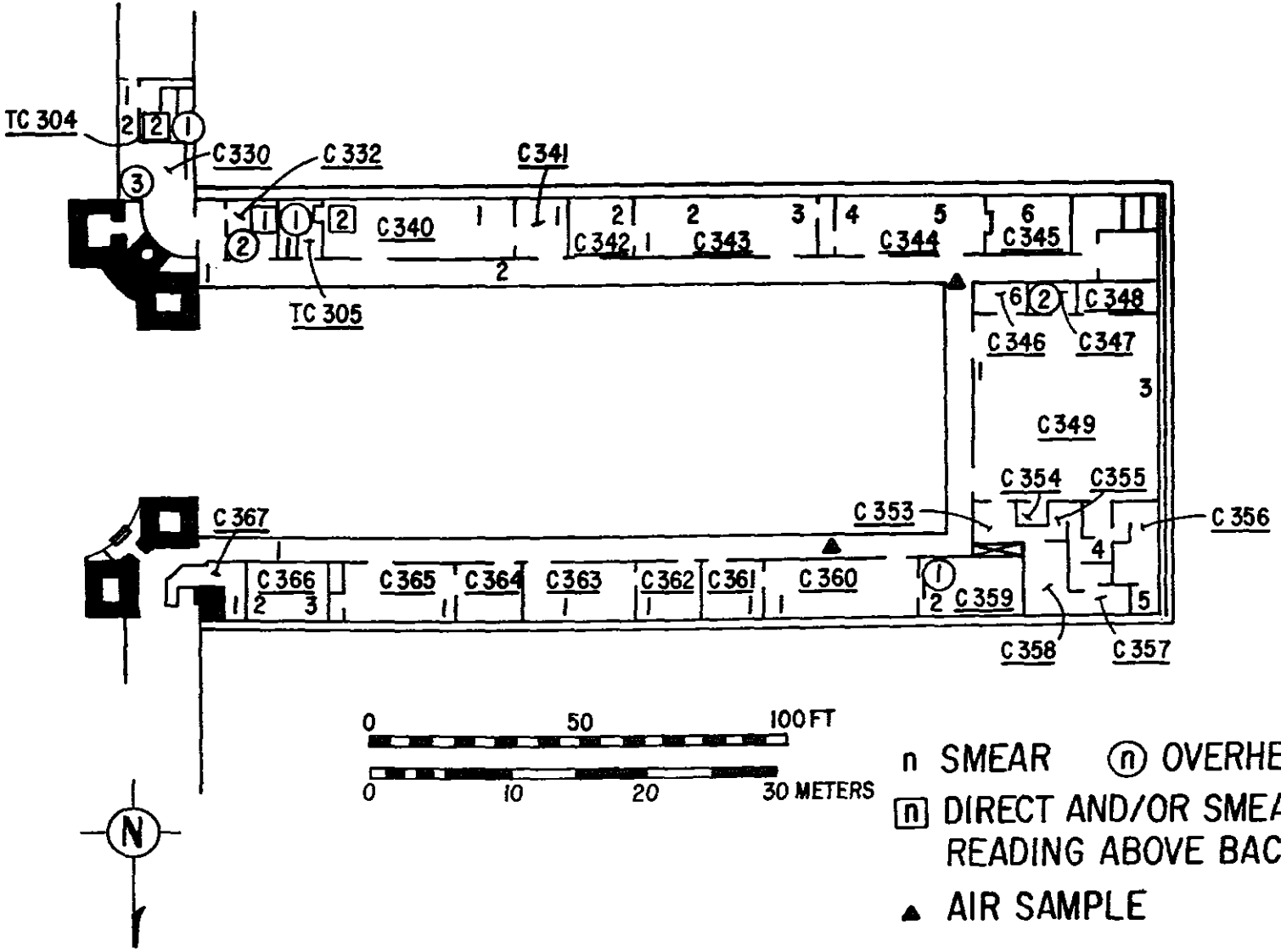


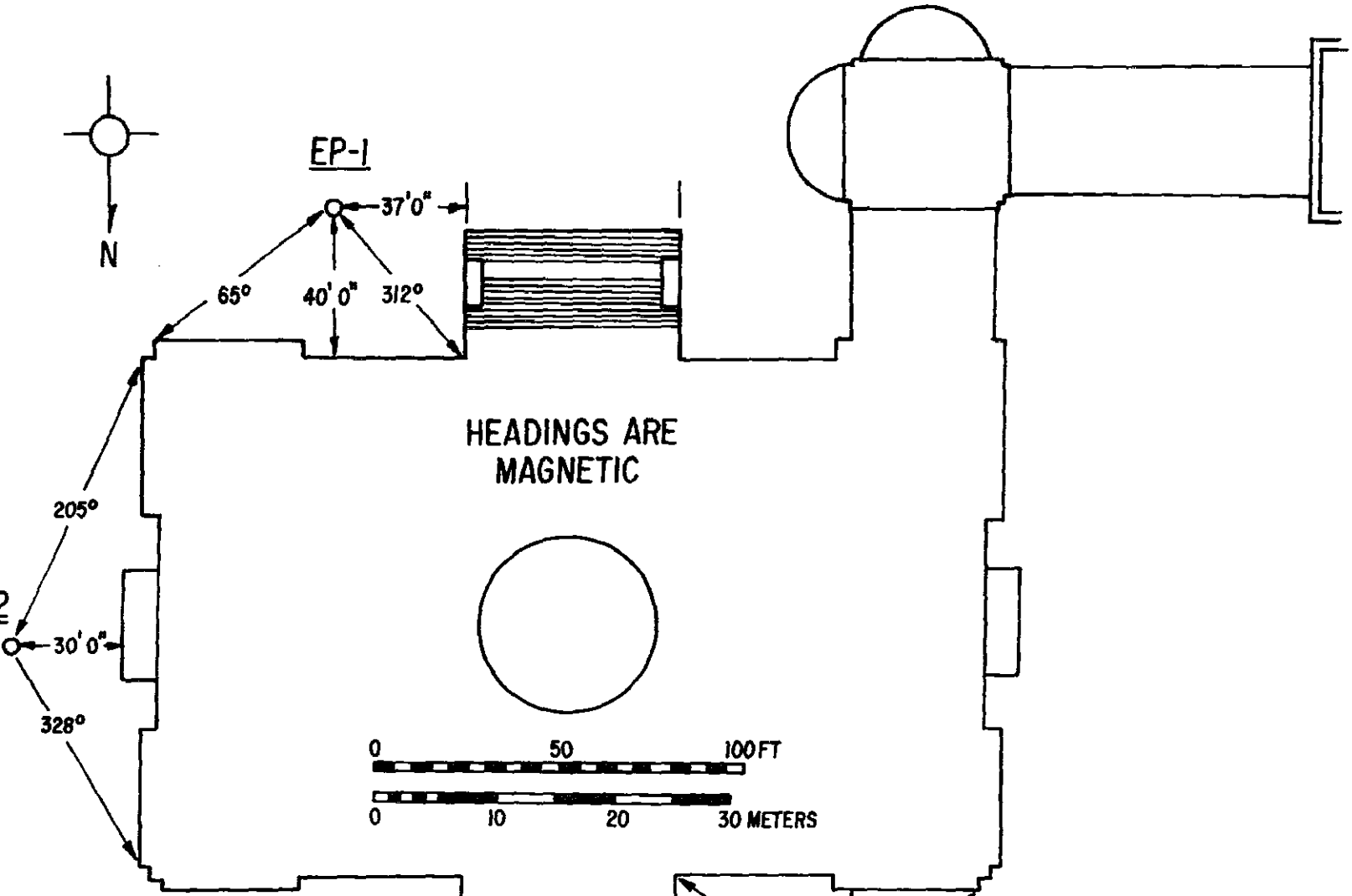
FIGURE 1D

SURVEY LOCATIONS OF EAST PAVILION - ROOF




TC 304
C 330
C 332
C 341
C 340
C 342
C 343
C 344
C 345
TC 305
C 348
C 346
C 347
C 349
C 354
C 355
C 356
C 353
C 367
C 366
C 365
C 364
C 363
C 362
C 361
C 360
C 359
C 358
C 357
0
50
100 FT
0
10
20
30 METERS
N
n SMEAR
(n) OVERHEAD SM
[n] DIRECT AND/OR SMEAR
READING ABOVE BACKGROU
▲ AIR SAMPLE

SURVEY LOCATIONS OF SOIL SAMPLES



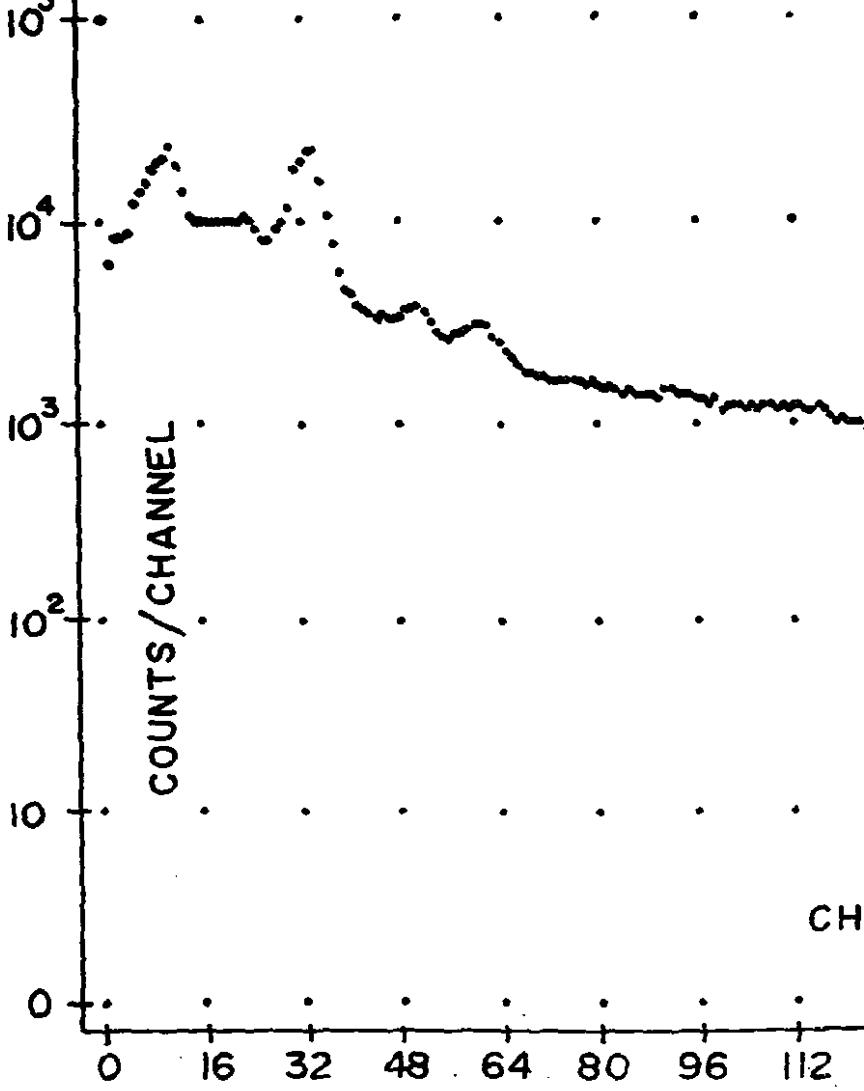
INSTRUMENTATION USED IN SURVEY

Type	Inventory Number	Probe Area	Window
Eberline Floor Monitor FM-4G utilizing a PAC-4G-3	181501	325cm^2	0.85mg/c
Eberline Floor Monitor FM-4G utilizing a PAC-4G-3	181581	325cm^2	"
PAC-4G-3	165251	61cm^2	"
"	165252	"	"
"	165255	"	"
"	165256	"	"
"	183413	"	"
"	183414	"	"
Eberline HP-90 Beta-Gamma End Window	159006	-	1.4 - 2m
Nuclear Measurement Corporation PC-3A-2π Internal Gas Flow Counter	114969	-	0.85mg/
Argonne National Laboratory Filter Queen Air Sampler using HV-70 filter media	-	-	-
Argonne National Laboratory 10 Wire Flat Plate Gas Proportional Detector with Eberline Mini Scaler MS-2	184343	-	0.85mg/

INSTRUMENT BACKGROUND READINGS

Instrument	Readings * Alpha Mode (cpm)	Beta Mode (cpm)
Eberline Floor Monitor FM-4G using PAC-4G-3		
#181501	0 - 50	1500 - 2000
#181581	0 - 50	1500 - 2000
PAC-4G-3		
#165251	0 - 50	150 - 200
#165252	"	"
#165255	"	"
#165256	"	"
#183413	"	"
#183414	"	"
Eberline HP-90 Beta-Gamma End Window		
Nuclear Measurement Corporation PC-3A-2π Internal Gas Flow Counter	0.4	50
Argonne National Laboratory 10 Wire Flat Plate Gas Proportional Detector with Eberline Mini Scaler MS-2	10	500

*Background readings were initially taken in the mobile laboratory an throughout the various areas inside the Museum of Science and Indust surveying.


10^4
10^3
10^2
10
0
COUNTS/CHANNEL
CH
0
16
32
48
64
80
96
112

RADON CONCENTRATION DETERMINATIONS

Location	dpm/M^3	pCi/l	% of MPC*
E-2	2744	1.25	42
E-14	1057	0.48	16
E-15	1057	0.48	16
E-18	3372	1.5	51
E-114	1075	0.49	16
E-117	1567	0.71	24
E-201	2277	1.04	35
E-202	1476	0.67	22
South Hall (2nd Balcony West Court)	683	0.31	10
North Hall (2nd Balcony West Court)	671	0.31	10

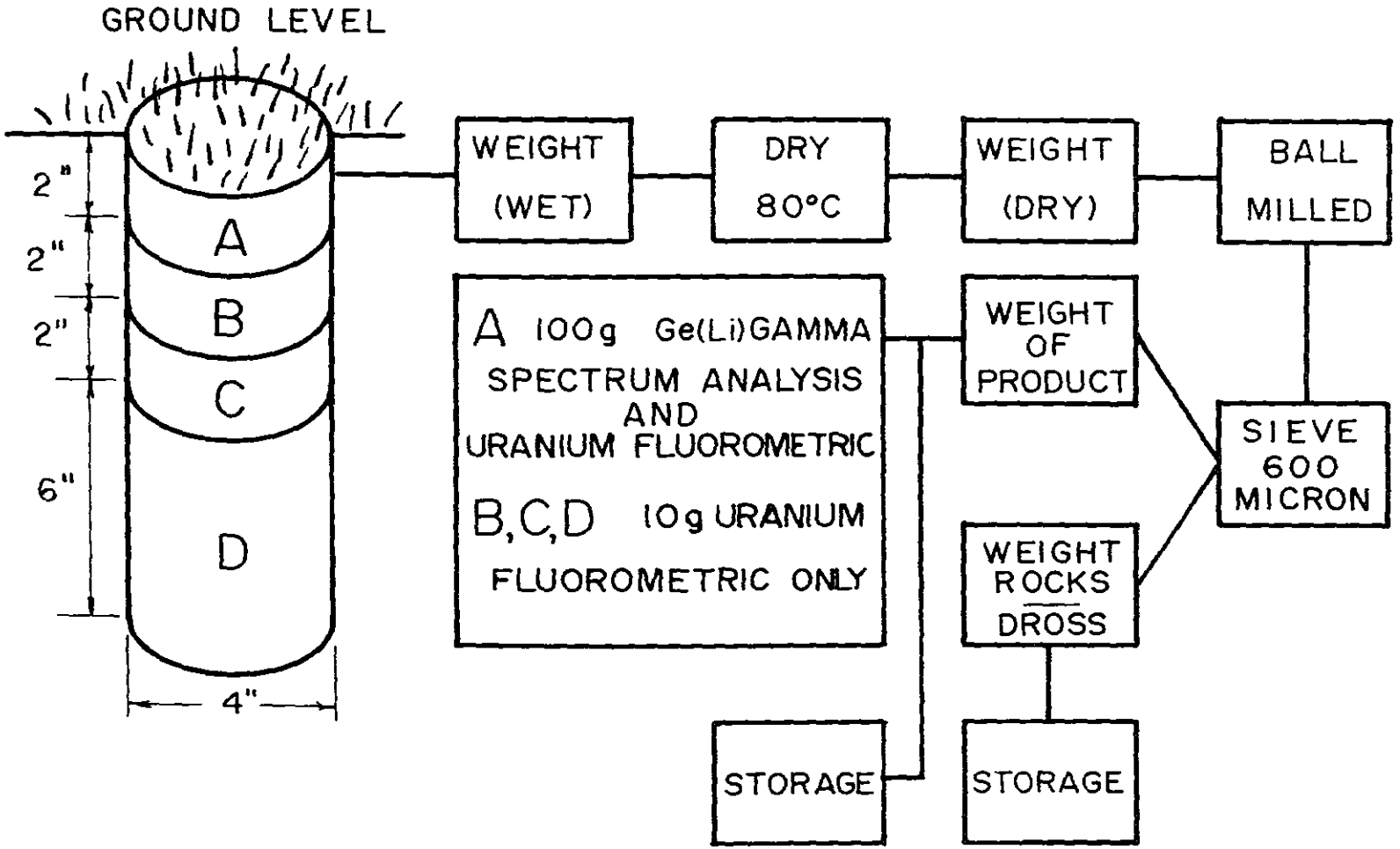
*The 10CFR20 MPC for Radon-222 (^{222}Rn) in an uncontrolled area is 3×10^{-9} µCi/cc which equals 3 pCi/l.

Example Calculation Room E-15

$$1057 \text{ dpm/M}^3 \times \frac{1 \text{ pCi}}{2.22 \text{ dpm}} \times \frac{M^3}{10^3 l} = 0.48 \text{ pCi/l}$$

FIGURE 3
SOIL SAMPLING PROCEDURE AND PROCESSING DIAGRAM

ANL-HP-DWG. 78-2



SOIL SAMPLE WEIGHTS

ample No.	Net Weight (grams)	Dry Weight (grams)	Sieved Weight (grams)	Rocks and I Weight (gra
P-1A	887.8	688.9	666.0	145.0
P-1B	749.0	582.0	551.6	3.5
P-1C	740.8	579.6	557.2	13.5
P-1D	1642.2	1281.8	1161.8	94.3
P-2A	616.1	435.2	376.0	55.3
P-2B	764.8	593.5	541.1	44.7
P-2C	1050.0	833.0	766.4	60.0
P-2D	2375.3	1944.5	1750.0	189.7
P-3A	677.8	495.9	417.1	72.2
P-3B	907.2	717.2	649.3	65.3
P-3C	962.3	785.5	750.4	26.9
P-3D	2142.2	1800.5	1563.3	222.9

TABLE 8

LFE SOIL ANALYSIS PROCEDURE FOR TOTAL URANIUM AND GAMMA-EMITTING NUCLIDES

ary of Methods

A 60 milliliter (ml) volume of the received soil was counted in a petri for 500 minutes on a Ge(Li) detector over the energy range 0 - 1.5 MeV. corresponded to between 60 to 100g of soil, depending upon bulk soil den tive photopeaks above instrument background were converted to dpm using a efficiency curve based upon a National Bureau of Standards Multi Gamma dard. The natural Thorium-232 (^{232}Th) and ^{226}Ra decay chains were calcul using the 0.910 MeV Actinium-228 (^{228}Ac) and 0.609 MeV Bismuth-214 (^{214}Bi opeaks respectively. Cesium-137 is reported for each sample as a represe gamma emitter. Potassium-40 (^{40}K) was observed on all soil samples, as cted, but was not calculated or reported.

One gram of the soil sample was ashed and dissolved in $HF-HNO_3$ for the t ium analysis. A 100-λ aliquot of the dissolved sample was fused with 98% 2% LiF and the fluorescence determined using a Jarrell-Ash fluorometer. ching factor was determined for each sample by using an internal spike.

Ge(Li) SPECTRUM AND URANIUM FLUOROMETRIC ANALYSES RESULTS

Sample No.	Ge(Li) Spectra pCi/g received wt ± σ(1)			U
	^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	μg/g ± σ(
EP-1A	1.43 ± 0.07	0.8 ± 0.2	0.75 ± 0.08	3.5±0.4
EP-1B				2.6±0.4
EP-1C				1.3±0.4
EP-1D				3.1±0.4
EP-2A	0.98 ± 0.05	0.9 ± 0.1	0.83 ± 0.07	2.2±0.4
EP-2B				2.2±0.5
EP-2C				1.9±0.6
EP-2D				1.9±0.4
EP-3A	1.05 ± 0.06	0.6 ± 0.2	0.93 ± 0.09	2.6±0.4
EP-3B				3.5±0.5
EP-3C				4.1±0.5
EP-3D				2.4±0.4
LFE Blank	0 ± 0.06	0 ± 0.1	0 ± 0.06	0±0.2

(1) One standard deviation due to counting statistics.

(2) Data Results from LFE.

(3) ANL Conversion from Appendix 3.

BACKGROUND SOIL SAMPLE DATA*

Cesium-137, Thorium, and Uranium in Soil 1976

concentrations in pCi/g

Date Collected	Location	Cesium-137	Thorium-232	Ur
July 22	Argonne Area	0.3 ± 0.1	0.21 ± 0.04	1
July 22	Argonne Area	0.1 ± 0.1	0.49 ± 0.04	2
July 22	Argonne Area	0.3 ± 0.1	0.48 ± 0.04	1
October 18	Argonne Area	0.1 ± 0.1	0.65 ± 0.07	1
October 18	Argonne Area	0.3 ± 0.1	0.43 ± 0.04	1
October 18	Argonne Area	0.4 ± 0.1	0.39 ± 0.04	1
	Average	0.2 ± 0.1	0.44 ± 0.14	1
	Off-Site			
June 22	McKinley Woods State Park, IL	0.4 ± 0.1	0.16 ± 0.02	0
June 23	McCormick Woods Brookfield, IL	0.3 ± 0.1	0.22 ± 0.02	1
June 23	Bemis Woods Hinsdale, IL	0.4 ± 0.1	0.18 ± 0.01	1
October 12	St. Joseph, MI	0.4 ± 0.1	0.20 ± 0.02	0
October 13	Willow Springs, IL	0.5 ± 0.2	-	1
October 14	Dresden Lock & Dam, IL	0.4 ± 0.1	0.45 ± 0.03	1
	Average	0.4 ± 0.1	0.24 ± 0.14	1

ese results are transcribed from "Environmental Monitoring at Argonne Nat
oratory Annual Report for 1976" (ANL-77-13) by N. W. Golchert, T. L. Duf
Sedlet. These measurements are presented in Table 13, on page 47 of the

CONVERSION FACTORS

INSTRUMENTATION

Below are the conversion factors used to obtain the readings in disintegrations per minute per 100cm^2 (dpm/100cm^2).

I Conversion Factors

	Floor Monitor (FM-4G)	PAC-4G-3
To 100cm^2	0.31	1.6
cpm to dpm (alpha)	2	2
cpm to dpm (beta)	2	2
cpm to dpm (K^{40})	-	16.5

II Derivation of Conversion Factors

Floor Monitor (FM-4G)

Window Area: ~325cm^2

Conversion to 100cm^2 = .31 times floor monitoring reading

PAC-4G-3

Window Area: ~61cm^2

Conversion to 100cm^2 = 1.6 times PAC reading

2π Internal Gas Flow Counter, PC-3A

Geometry: Mylar Spun Top - 0.43

Mylar Spun Top Counting (window double aluminized m
mg/cm^2) utilizes the well of the PC-3A and is a met
and used by the Argonne National Laboratory Health
Section for negating the dielectric effect in count
on non-conducting media.

The conversion factors for cpm/100cm^2 to dpm/100cm^2 are given below.

I CONVERSION EQUATION (ALPHA)

$$\frac{\text{cpm-Bkgd}}{\text{g x bf x sa x waf}} = \text{dpm Alpha}$$

geometry (g) of 0.43 is standard for all flat plate counting.

backscatter factor (bf) of 1.0 is used when determining alpha activity o
filter media.

ne self-absorption (sa) was assumed to be 1 unless otherwise determined.

f the energies of the isotope were known, the appropriate window air fact
vaf) was used; if the energies of the isotopes were unknown the waf of ^{23}
hich is .713, was used.

II CONVERSION EQUATION (BETA)

$$\frac{\text{pm - (Beta Bkgd + Alpha cpm)}}{\text{g x bf x sa x waf}} = \text{dpm Beta}$$

geometry (g) of 0.43 is standard for all flat plate counting.

backscatter factor (bf) of 1.1 is used when determining beta activity on
ilter media.

ne self-absorption (sa) was assumed to be 1 unless otherwise determined.

the energies of the isotopes were known, the appropriate window air fac
vaf) was used; if the energies of the isotopes were unknown, the waf of
^{90}Sr-^{90}Y, which is 0.85 was used.

RADON DETERMINATION

This attachment summarizes the air sampling calculations for samples llected using Argonne National Laboratory designed air sampler with HV-70 lter media. The attachment includes the basic assumptions and calcula- ons used to derive the air concentrations.

Radon Concentrations Based on RaC' Results

The following postulates are assumed in deriving the Radon-222 (^{222}Rn) concentrations as based on the RaC' alpha count results.

1. RaA, RaB, RaC, RaC', are in equilibrium.

2. RaA is evident only in the first count and not the 100 minute decay count.

3. That one-half of the Radon progeny is not adhered to airborne particulate, and therefore, not evident on the filter media.

4. The geometry factor (g) is 0.43 for both the alpha and beta activity.

5. The backscatter factor (bf) of 1.0 is used for the alpha activity which is determined from RaC'.

6. The sample absorption factor (sa) for RaC' is 0.77.

7. The window air factor (waf) for RaC' is 0.8.

8. RaB and RaC being beta emitters, are not counted in the alpha mode.

9. The half-life of the Radon progeny is approximately 36 minutes, based on the combined RaB and RaC half-lives.

10. No long-lived alpha emitters present as evidenced by the final recount.

11. For all practical purposes, RaC' decays at the rate of the composit of RaB and RaC which is approximately 36 minutes.

II. Equations Used to Derive Air Concentrations

$$N_o = \frac{N}{e^{-\lambda t}}$$

Where: N_o = Activity present at the end of the sampling pe

N = Activity at some time interval, after end of s

t = Time interval N_o to N

$$\lambda = \frac{.693}{t_{1/2}}$$

$t_{1/2}$ = Half-life of isotope

$$C = \frac{A\ \lambda}{f}\ \frac{1}{(1-e^{-\lambda t})}$$

Where: C = Concentration per unit volume

A = Activity of filter media at end of sampling pe (N_o from previous equation)

f = Sampling rate (M^3/minute)

t = Time sampling was taken

$$\lambda = \frac{.693}{t_{1/2}}$$

$t_{1/2}$ = Half life of isotope or controlling parent

I. Example Calculations - Room E-15

$$N_o = \frac{498 \text{ dpm}}{e^{-\frac{.693 \times 104}{36}}} = 3687 \text{ dpm}$$

$$C = \frac{3687 \times \frac{.693}{36}}{15/60} \frac{}{1-e^{-\frac{.693 \times 40}{36}}} = 529 \text{ dpm/M}^3 \times 2 = 1057 \text{ dpm/M}^3$$

CATION: MUSEUM OF SCIENCE AND INDUSTRY E-2

SAMPLE COLLECTION DATE: 4/15/77

TIME OF COLLECTION: 1242

SUSPECTED ISOTOPE: Unidentified

NGTH OF RUN: TIME STOPPED 1322 MINUS TIME STARTED 1242 TOTAL TIME 40 MINUTES

LUME: COLLECTION RATE $\frac{15}{60}$ M^3/hr X TOTAL TIME 40 MINUTES = VOLUME 10 M^3

TE AND TIME OF COUNT	GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M^3	TYPE OF ACTIVITY	DECAY TIM
1324	118	2	59	0.03	59	.43	1	.77	.8	2226	223	α	2 min.
1502	74	2	37	0.03	37	.43	1	.77	.8	1396	140	α	100 min.
1300	0	2	0	0.5	BKGD.	.43	1	.77	.8	BKGD.	BKGD.	α	6 days
1326	2114	2	1057	$\pm \frac{47.3}{59}$	590.7	.43	1.1	1	.95	21,174	2117	β	4 min.
1504	634	2	317	$\pm \frac{47.3}{37}$	232.7	.43	1.1	1	.95	5182.6	518	β	102 min.
1300	80	2	40	53.3	BKGD.	.43	1.1	1	.95	BKGD.	BKGD.	β	6 days

HA:

$\frac{\text{cpm - Bkdg}}{\quad}$ = dpm Alpha

BETA: Pure Beta emitters

$\frac{\text{cpm - Bkgd}}{\quad}$ = dpm Beta

COMPOSITE: Beta determination

$\frac{\text{cpm - Beta Bkgd + Alpha cpm}}{\quad}$ = dpm Beta

APPENDIX 2B

AIR SAMPLE DATA

LOCATION: MUSEUM OF SCIENCE AND INDUSTRY E-14

SAMPLE COLLECTION DATE: 2/1/7

TIME OF COLLECTION: 1046

SUSPECTED ISOTOPE: Unidentif

LENGTH OF RUN: TIME STOPPED 1126 MINUS TIME STARTED 1046 TOTAL TIME 40 MINUTES

VOLUME: COLLECTION RATE $\frac{15}{60}$ M^3/hr X TOTAL TIME 40 MINUTES = VOLUME 40 M^3

DATE AND TIME OF COUNT		GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M^3	TYPE OF A
2/1	1135	176	2	88	0.3	87.7	.43	1	.77	.8	3311	331	α
2/1	1315	27	2	13.5	0.3	13.2	.43	1	.77	.8	498	50	α
4/21	1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α
2/1	1133	909	2	455	91.6 + 88.	275.4	.43	1.1	1	.95	6133	613	β
2/1	1313	384	2	192	91.6 + 13.5	85.9	.43	1.1	1	.95	1935	4	β
4/21	1300	68	2	34	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β

ATION: MUSEUM OF SCIENCE AND

TIME OF COLLECTION: 1149

SUSPECTED ISOTOPE: Unidentified

GTH OF RUN: TIME STOPPED 1229 MINUS TIME STARTED 1149 TOTAL TIME 40 MINUTES

UME: COLLECTION RATE $\frac{15\ M^3/hr}{60}$ X TOTAL TIME 40 MINUTES = VOLUME 10 M^3

CE AND TIME OF COUNT	GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY TIM
1233	179	2	89.5	0.3	89.2	.43	1	.77	.8	3366	337	α	4 min
1413	27	2	13.5	0.3	13.2	.43	1	.77	.8	498	50	α	104 min
1300	1	2	0.5	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	79 days
1235	929	2	462	91.6 + 89.5	280.9	.43	1.1	1	.95	6256	626	β	6 min
1415	291	2	145.5	91.6 + 13.5	40.4	.43	1.1	1	.95	899	90	β	106 min
	87	2	43.5	54.0	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	79 days

LPHA:

$\frac{\text{cpm - Bkdg}}{\text{g x bf x sa x waf}}$ = dpm Alpha

BETA: Pure Beta emitters

$\frac{\text{cpm - Bkgd}}{\text{g x bf x sa x waf}}$ = dpm Beta

COMPOSITE: Beta determination

$\frac{\text{cpm - Beta Bkgd + Alpha cpm}}{\text{g x bf x sa x waf}}$ = dpm Be

AIR SAMPLE DATA

ATION: MUSEUM OF SCIENCE AND INDUSTRY E-18

SAMPLE COLLECTION DATE: 2/16/77

TIME OF COLLECTION: 1100

SUSPECTED ISOTOPE: Unidentified

GTH OF RUN: TIME STOPPED 1140 MINUS TIME STARTED 1100 TOTAL TIME 40 MINUTES

UME: COLLECTION RATE $\frac{15}{60}$ M^3/hr X TOTAL TIME 40 MINUTES = VOLUME 10 M^3

E AND TIME OF COUNT	GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY TIME
1150	292	2	146	0.5	145.5	.43	1	.77	.8	5490	549	α	10 min
1330	76	2	38	0.5	37.5	.43	1	.77	.8	1415	145	α	110 min
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	64 days
1152	1599	2	799	$\frac{87}{+\ 146}$	566	.43	1.1	1	.95	12605	1261	β	12 min
1332	466	2	233	$\frac{87}{+\ 38}$	108	.43	1.1	1	.95	2405	241	β	112 min
1300	99	2	43.5	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	64days

LA: BETA: Pure Beta emitters COMPOSITE: Beta determination

CATION: MUSEUM OF SCIENCE AND INDUSTRY 114

SAMPLE COLLECTION DATE: 3/2/77

TIME OF COLLECTION: 1030

SUSPECTED ISOTOPE:

NGTH OF RUN: TIME STOPPED 1110 MINUS TIME STARTED 1030 TOTAL TIME 40 MINUTES

LUME: COLLECTION RATE $\frac{15}{60}$ M^3/hr X TOTAL TIME 40 MINUTES = VOLUME 10 M^3

TE AND TIME OF COUNT	GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY T
1119	1555	2	77.5	0.3	77.2	.43	1	.77	.8	2913	291	α	9 min
1259	25	2	12.5	0.3	12.2	.43	1	.77	.8	460	46	α	109 min
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	50 days
1117	853	2	426.5	$\pm \frac{83}{77.5}$	266	.43	1.1	1	.95	5924	592	β	7 min
1257	284	2	142	$\pm \frac{83}{12.5}$	46.5	.43	1.1	1	.95	1035	4	β	107 min
1300	64	2	32	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	50 days

PHA:
cpm - Bkdg

BETA: Pure Beta emitters
cpm - Bkgd

COMPOSITE: Beta determination
cpm - Beta Bkgd + Alpha cpm

AIR SAMPLE DATA

CATION: MUSEUM OF SCIENCE AND INDUSTRY E-117 South

SAMPLE COLLECTION DATE: 3/1/77

TIME OF COLLECTION: 1026

SUSPECTED ISOTOPE: Unidentified

NGTH OF RUN: TIME STOPPED 1106 MINUS TIME STARTED 1026 TOTAL TIME 40 MINUTES

LUME: COLLECTION RATE $\frac{15}{60}$ M^3/hr X TOTAL TIME 40 MINUTES = VOLUME 10 M^3

E AND TIME OF COUNT	GROSS COUNTS			BKGD	NET								
	TOTAL COUNTS	COUNT TIME Min.	COUNTS / MIN.	COUNTS / MIN.	COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY TIME
1111	149	2	74.5	0.5	74.0	.43	1	.77	.8	2792	279	α	5 min
1251	59	2	19.7	0.5	19.2	.43	1	.77	.8	724	72	α	105 min
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	51 days
1113	835	2	417.5	$\frac{79}{2}$ +74.5	264	.43	1.1	1	.95	5879	588	β	7 min
1253	426	2	142	$\frac{79}{2}$ +19.7	43.3	.43	1.1	1	.95	964	96	β	107 min
1300	42	2	21	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	51 days

TION: MUSEUM OF SCIENCE AND INDUSTRY

TIME OF COLLECTION: 1100

SUSPECTED ISOTOPE: Unidentified

GTH OF RUN: TIME STOPPED 1142 MINUS TIME STARTED 1100 TOTAL TIME 42 MINUTES

UME: COLLECTION RATE 15 M^3/hr x TOTAL TIME 42 MINUTES / 60 = VOLUME 10.5 M^3

TE AND TIME OF COUNT	GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY TIME
1149	312	2	156	0.2	155.8	.43	1	.77	.8	5879	560	α	7 min
1338	47	2	23.5	0.2	23.3	.43	1	.77	.8	879	84	α	116 min
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	36 days
1151	1526	2	762	57.8 + 156	549.2	.43	1.1	1	.95	12231	1165	β	9 min
1340	337	2	168.5	57.8 + 23.5	87.2	.43	1.1	1	.95	1942	185	β	118 min
1300	42	2	21	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	36 days

LPHA:

$\frac{\text{cpm - Bkdg}}{\text{g x bf x sa x waf}}$ = dpm Alpha

BETA: Pure Beta emitters

$\frac{\text{cpm - Bkgd}}{\text{g x bf x sa x waf}}$ = dpm Beta

COMPOSITE: Beta determination

$\frac{\text{cpm - Beta Bkgd + Alpha cpm}}{\text{g x bf x sa x waf}}$ = dpm Bet